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(54) **MEDIA-CONFERENCING SERVICE AND INTERNET-ACCESS SERVICE FROM A FIFTH GENERATION NEW RADIO LONG TERM EVOLUTION (5G NR/LTE) WIRELESS ACCESS POINT**

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H04W 76/10 (2018.01)
H04M 3/56 (2006.01)
H04W 88/16 (2009.01)

(52) **U.S. Cl.**
CPC **H04W 76/10** (2018.02); **H04M 3/567** (2013.01); **H04W 88/16** (2013.01)

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CPC H04W 4/70; H04W 48/00; H04W 76/18; H04W 76/27; H04L 47/41
See application file for complete search history.

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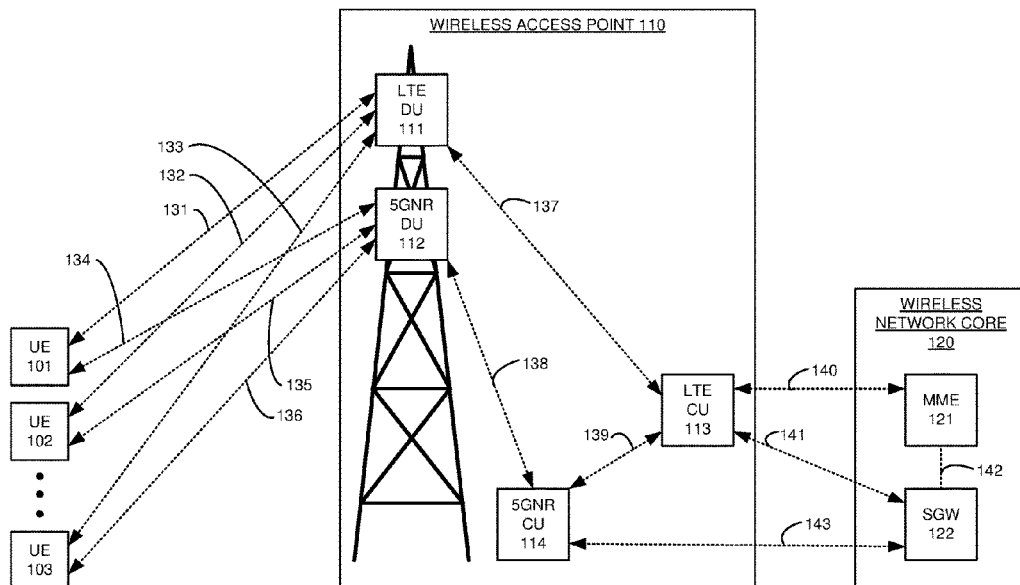
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Primary Examiner — Melanie Jagannathan

(57) **ABSTRACT**

In a wireless access point, a Long Term Evolution (LTE) Common Unit (CU) exchanges media-conferencing data with an LTE Distributed Unit (DU). The LTE DU exchanges the media-conferencing data User Equipment (UEs). The LTE CU determines a media-conferencing load. Based on the media-conferencing load, the LTE CU determines a Fifth Generation New Radio (5G NR) Uplink (UL) allocation and an LTE UL allocation for an internet-access service. The LTE CU transfers LTE signaling and 5G NR signaling for delivery to the UEs. The LTE DU receives LTE UL internet data from the UEs per the LTE UL allocation and transfers the LTE UL internet data to the LTE CU. The 5G NR DU receives 5G NR UL internet data from the UEs per the 5G NR UL allocation and transfers the 5G NR UL internet data to the 5G NR CU. The LTE CU may also implement 5G NR/LTE downlink allocations for the internet-access service based on the media-conference load.

20 Claims, 7 Drawing Sheets



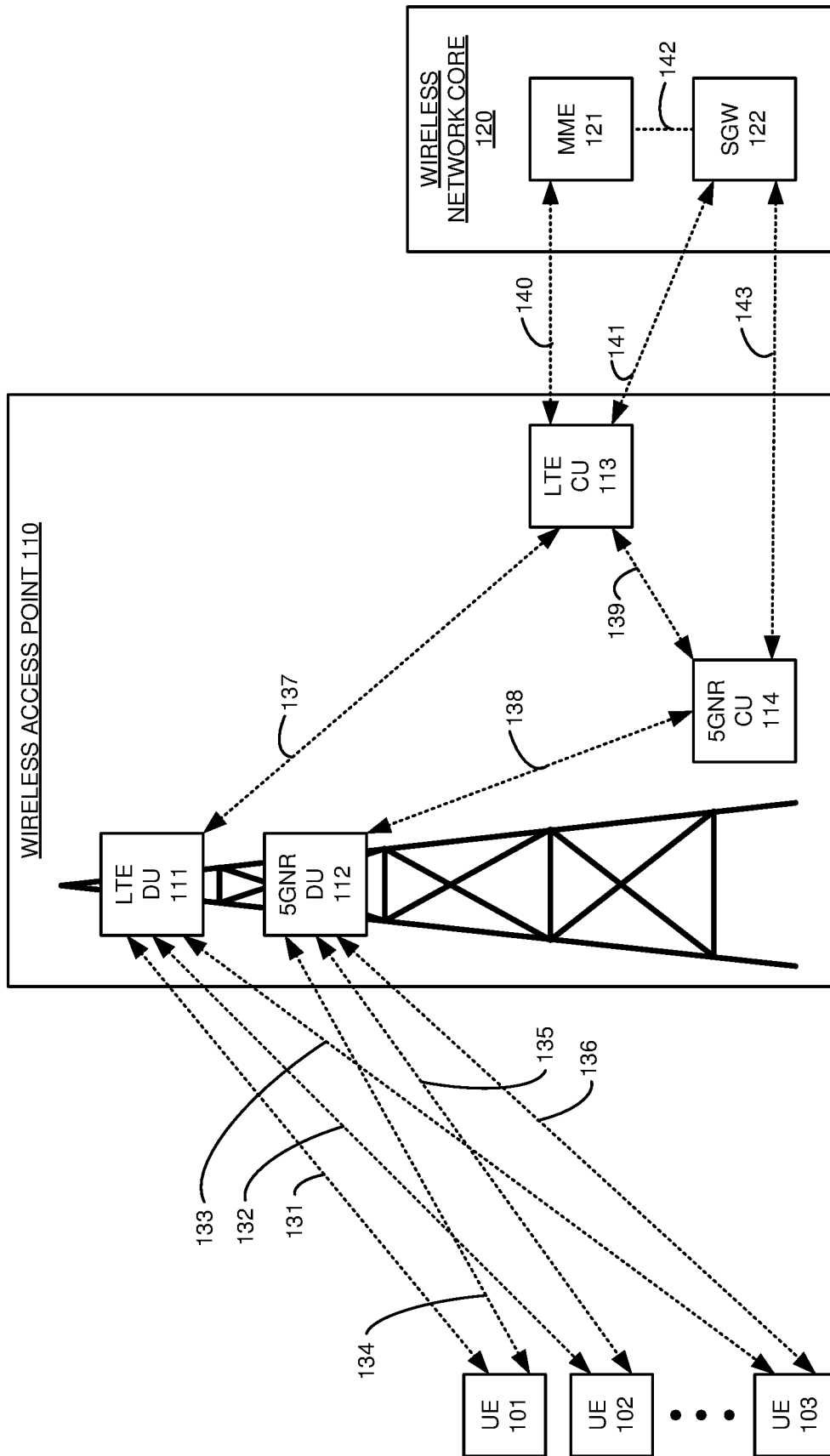


FIGURE 1

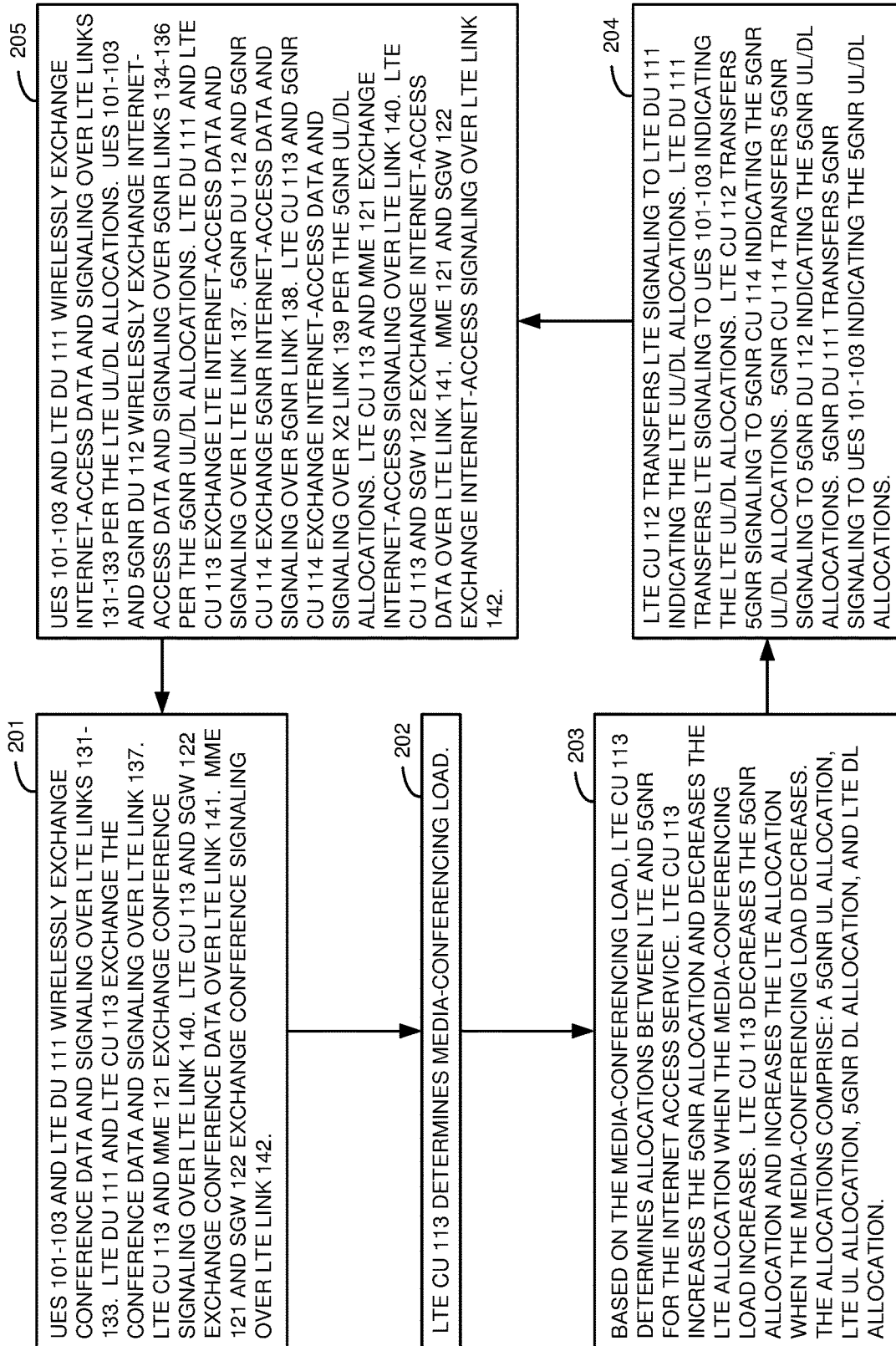


FIGURE 2

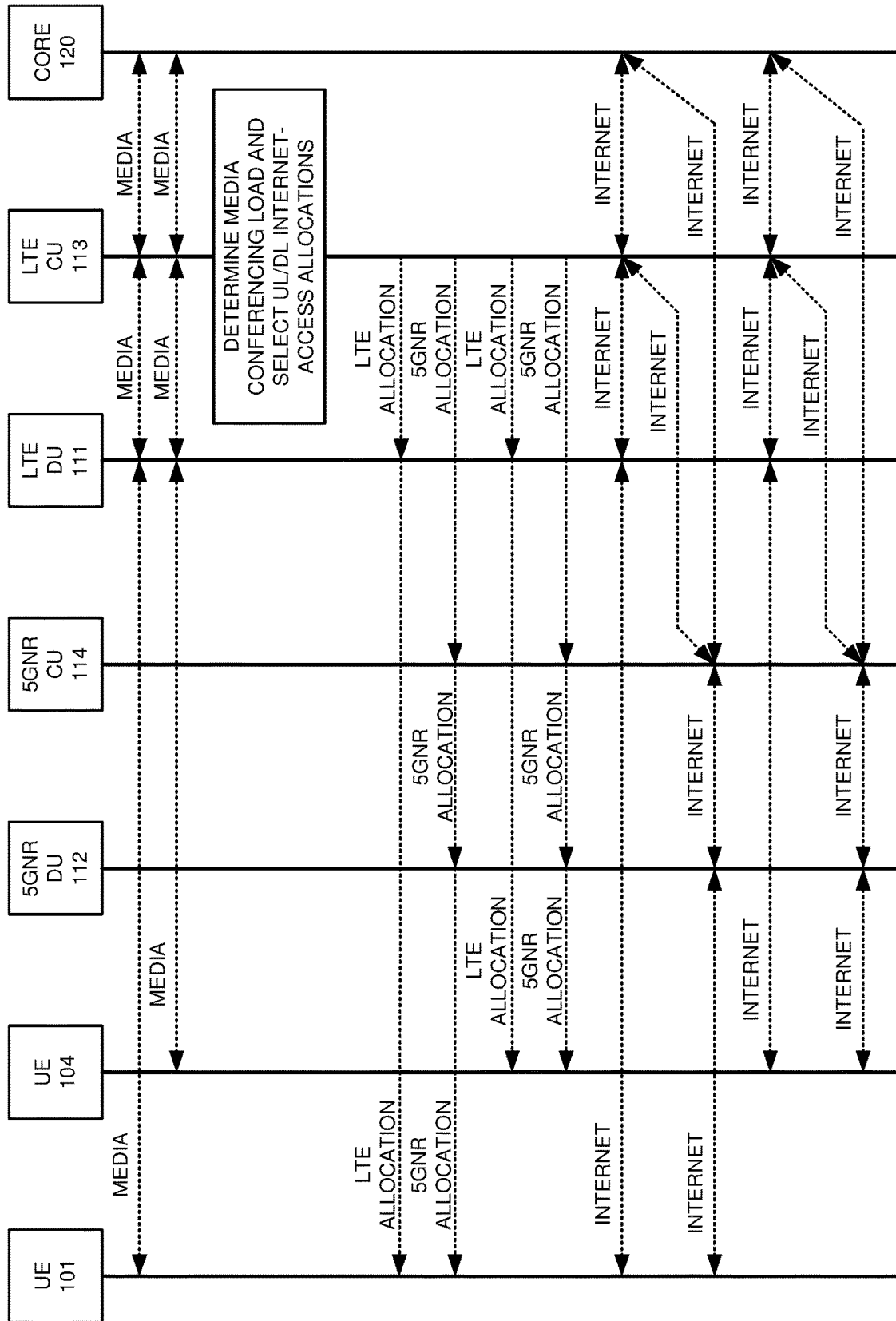


FIGURE 3

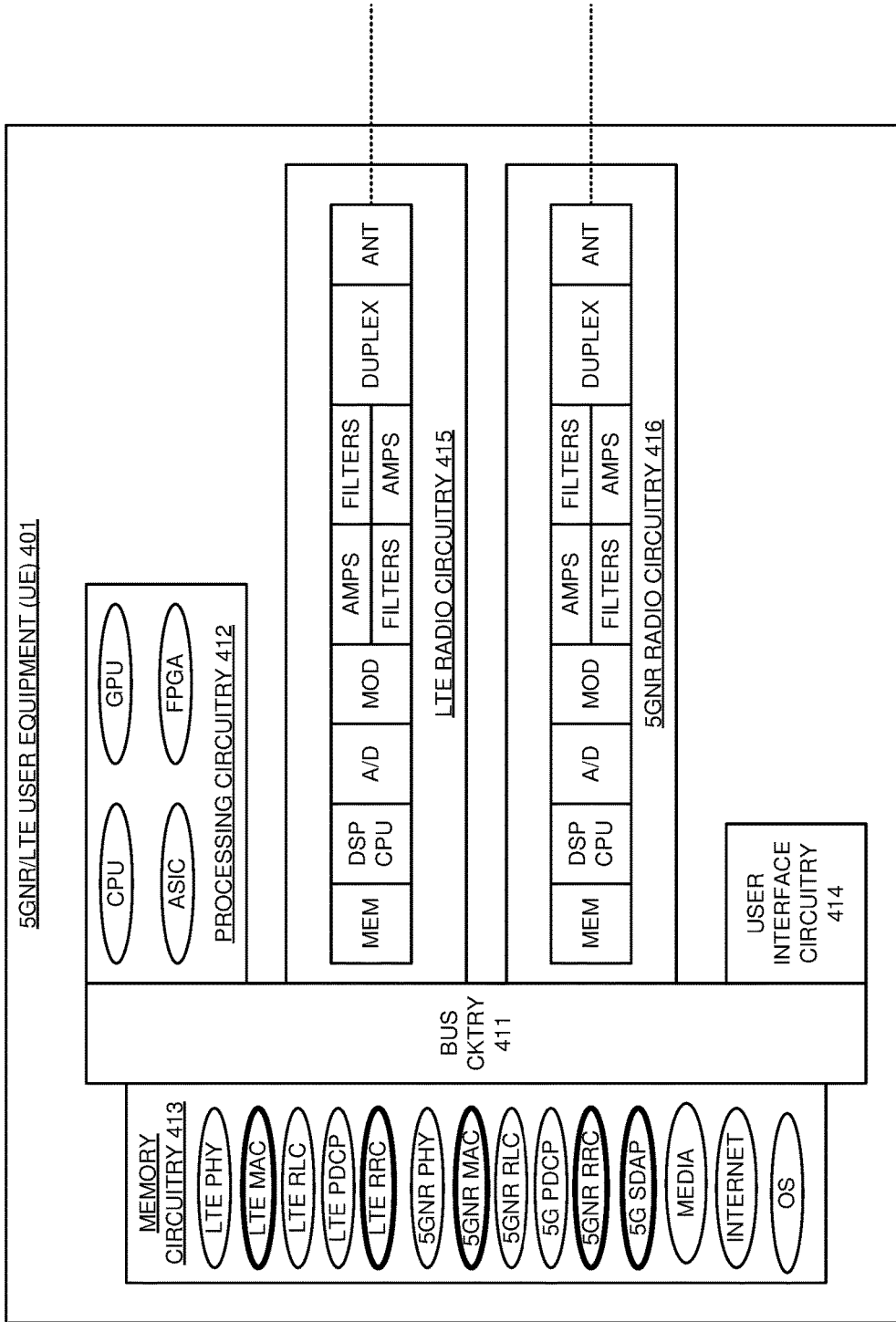


FIGURE 4

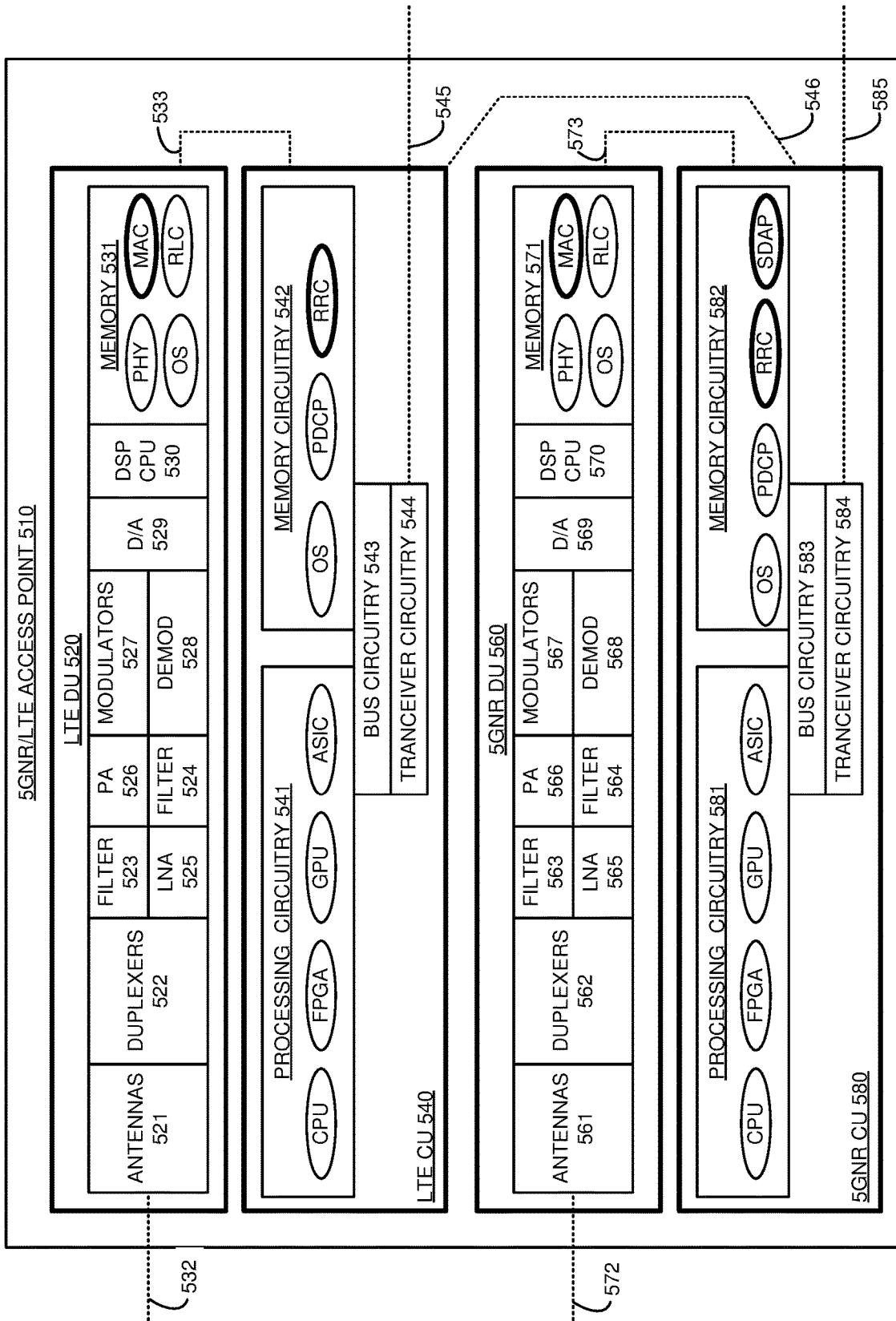


FIGURE 5

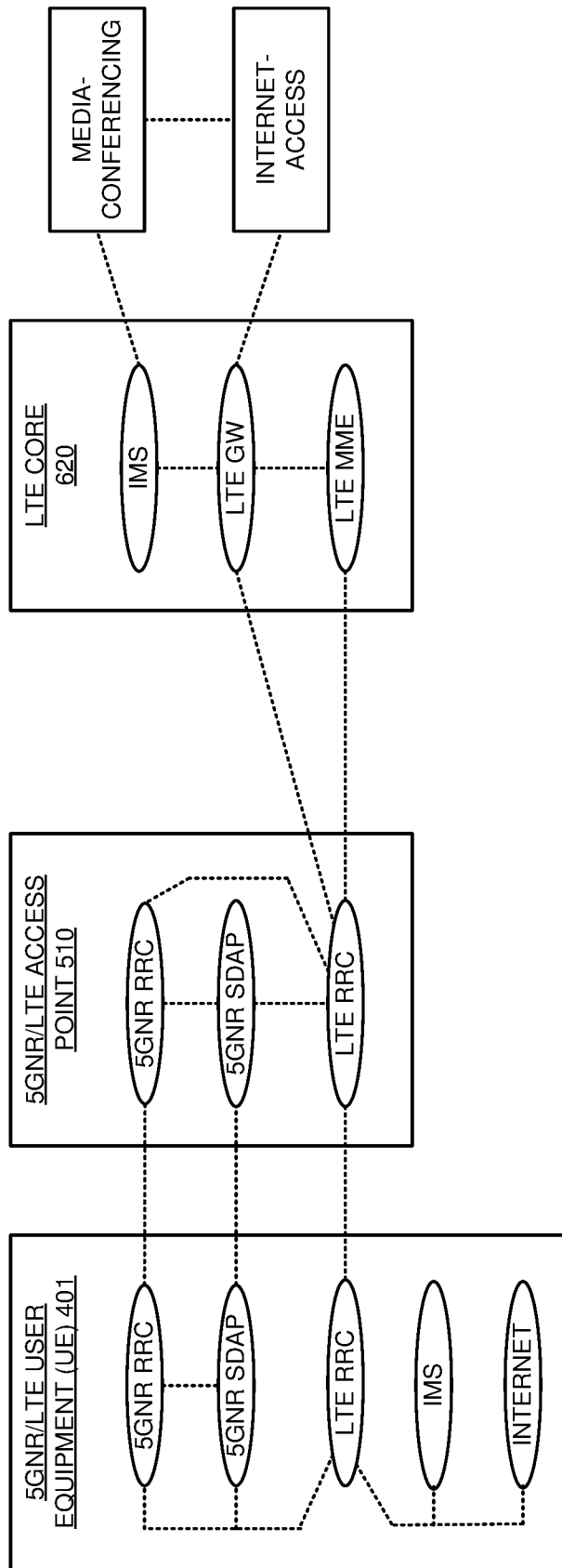


FIGURE 6

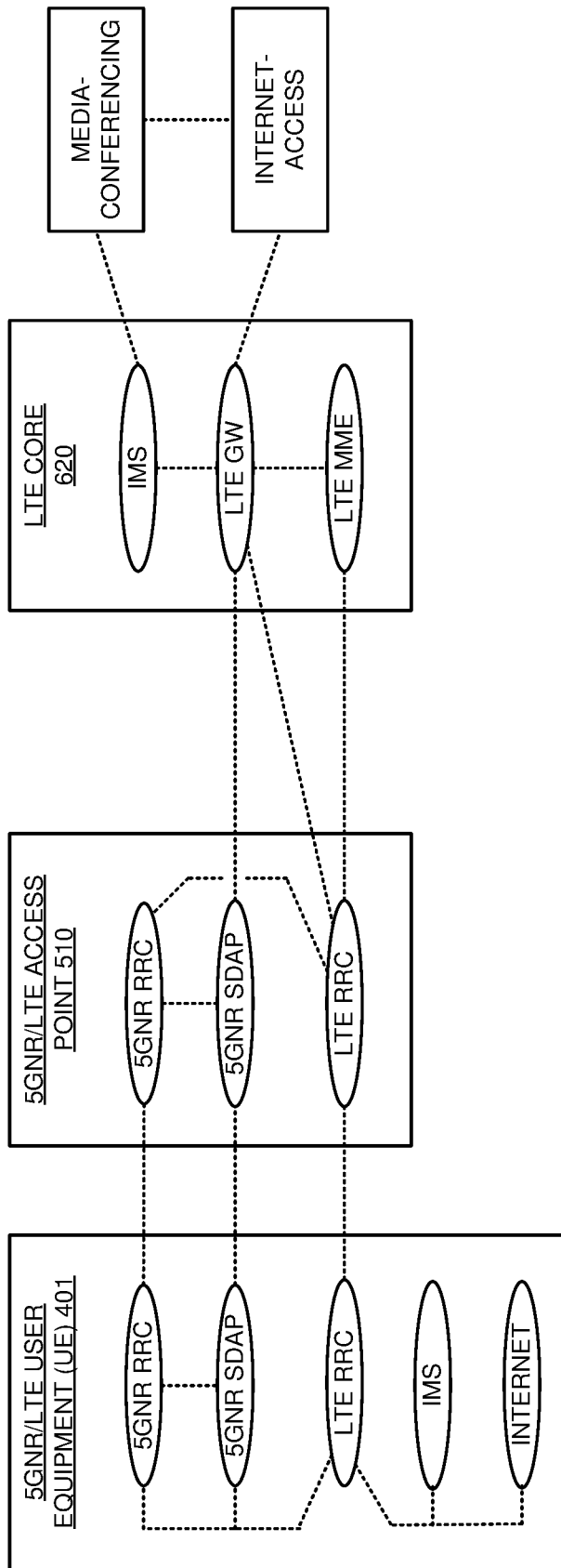


FIGURE 7

MEDIA-CONFERENCING SERVICE AND INTERNET-ACCESS SERVICE FROM A FIFTH GENERATION NEW RADIO LONG TERM EVOLUTION (5G NR/LTE) WIRELESS ACCESS POINT

TECHNICAL BACKGROUND

Wireless user devices exchange wireless signals with wireless communication networks for data services like voice-calling and internet-access. The wireless communication networks have wireless access points that exchange the wireless signals with the wireless user devices. Popular forms of wireless networking comprise Long Term Evolution (LTE) and Fifth Generation New Radio (5G NR).

When an LTE user device attaches to an LTE access point, the LTE access point interacts with an LTE network core to authorize and establish an internet-access bearer and an Internet Protocol Multimedia Subsystem (IMS) bearer for the LTE user device. The LTE user device exchanges user data over the internet using the internet-access bearer. The LTE user device exchanges Session Initiation Protocol (SIP) signaling with an IMS server over the IMS bearer to establish media-conferencing bearers. The LTE user device exchanges conference data like live voice and video over the LTE media-conferencing bearers.

When a dual 5G NR/LTE user device attaches to an integrated 5G NR/LTE access point, the 5G NR/LTE access point interacts with the LTE core to authorize and establish a 5G NR/LTE internet-access bearer and LTE IMS bearer for the 5G NR/LTE user device. The 5G NR/LTE internet-access bearer uses parallel LTE and 5G NR links between the 5G NR/LTE UE and the 5G NR/LTE access point. The 5G NR/LTE user device uses the parallel LTE and 5G NR links to exchange user data over the internet. The 5G NR/LTE user device exchanges SIP signaling with the IMS server over the LTE IMS bearer to establish an LTE media-conferencing bearer. The 5G NR/LTE user device exchanges conference data like live voice and video over the LTE media-conferencing bearer.

Unfortunately, the 5G NR/LTE access point does not transfer internet data over the parallel LTE and 5G NR links to efficiently and effectively support the media-conferencing service.

TECHNICAL OVERVIEW

In a wireless access point, a Long Term Evolution (LTE) Common Unit (CU) exchanges media-conferencing data with an LTE Distributed Unit (DU). The LTE DU exchanges the media-conferencing data User Equipment (UEs). The LTE CU determines a media-conferencing load. Based the media-conferencing load, the LTE CU determines a Fifth Generation New Radio (5G NR) Uplink (UL) allocation and an LTE UL allocation for an internet-access service. The LTE CU transfers LTE signaling and 5G NR signaling for delivery to the UEs. The LTE DU receives LTE UL internet data from the UEs per the LTE UL allocation and transfers the LTE UL internet data to the LTE CU. The 5G NR DU receives 5G NR UL internet data from the UEs per the 5G NR UL allocation and transfers the 5G NR UL internet data to the 5G NR CU. The LTE CU may also implement 5G NR/LTE downlink allocations for the internet-access service based on the media-conference load.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a wireless access point that wirelessly serves User Equipment (UEs) with a media-conferencing service and an internet-access service.

FIG. 2 illustrates the operation of the wireless access point to wirelessly serve the UEs with the media-conferencing service and the internet-access service.

FIG. 3 illustrates the operation of the wireless access point to wirelessly serve the UEs with the media-conferencing service and the internet-access service.

FIG. 4 illustrates a UE that is wirelessly served by a wireless access point with a media-conferencing service and an internet-access service.

FIG. 5 illustrates a wireless access point to wirelessly serve UEs with a media-conferencing service and an internet-access service.

FIG. 6 illustrates the operation of the UE, wireless access point, and network core to serve the UE with the media-conferencing service and the internet-access service.

FIG. 7 illustrates the operation of the UE, wireless access point, and network core to serve the UE with the media-conferencing service and the internet-access service.

DETAILED DESCRIPTION

FIG. 1 illustrates wireless access point 110 that wirelessly serves User Equipment (UEs) 101-103 with a media-conferencing service and an internet-access service. Wireless access point 110 comprises Long Term Evolution (LTE) Distributed Unit (DU) 111, Fifth Generation New Radio (5G NR) DU 112, LTE Common Unit (CU) 113, and 5G NR CU 114. Wireless network core comprises Mobility Management Entity (MME) 121 and Serving Gateway (SGW) 122. The number of UEs that are depicted on FIG. 1 has been restricted for clarity, and wireless access point 110 serves many more UEs that are like UEs 101-103.

UEs 101-103 and LTE DU 111 communicate over respective LTE links 131-133. UEs 101-103 and 5G NR DU 112 communicate over respective 5G NR links 134-136. LTE DU 111 and LTE CU 113 communicate over LTE link 137. 5G NR DU 112 and 5G NR CU 114 communicate over 5G NR link 138. LTE CU 113 and 5G NR CU 114 communicate over X2 link 139. LTE CU 113 and MME 121 communicate over LTE link 140. LTE CU 113 and SGW 122 communicate over LTE link 141. MME 121 and SGW 122 communicate over LTE link 142. In some examples, 5G NR CU 114 and SGW 122 communicate over 5G NR link 143, although 5G NR link 143 is omitted in other examples.

UEs 101-103 might be phones, computers, robots, vehicles, sensors, and/or the like. UEs 101-103 comprise radio circuitry and user circuitry. The radio circuitry comprises antennas, modulators, amplifiers, filters, digital/analog interfaces, processing circuitry, memory circuitry, and bus circuitry. The user circuitry comprises processing circuitry, memory circuitry, bus circuitry, user interfaces, and the like. The memory circuitry stores software that includes operating systems, network applications, and user applications. The network applications comprise Physical Layer (PHY), Media Access Control (MAC), Radio Link Control (RLC), Packet Data Convergence Protocol (PDCP), Radio Resource Control (RRC), and Service Data Application Protocol (SDAP), or some other networking protocol stack. The processing circuitry executes the operating systems, network applications, and user applications to wirelessly exchange user data and network signaling with wireless access point 110.

Wireless access point 110 comprises transceiver circuitry and networking circuitry. The transceiver circuitry comprises antennas, modulators, amplifiers, filters, digital/analog interfaces, processing circuitry, and memory. The processing circuitry comprises Digital Signal Processors

(DSPs), Central Processing Units (CPUs), Graphical Processing Units (GPUs), Field Programmable Gate Arrays (FPGAs), Application Specific Integrated Circuits (ASICs) and/or the like. The memory circuitry comprises Random Access Memory (RAM), flash memory, disk drives, and/or the like. The memory circuitry stores software like operating systems and network applications. The network applications comprise PHY, MAC, RLC, PDCP, RRC, and SDAP or some other network protocol stack. The processing circuitry executes the operating systems and network applications to wirelessly exchange user data and network signaling with UEs **101-103** and to exchange user data and network signaling with wireless network core **120**.

Wireless network core **120** comprises processing circuitry, memory circuitry, bus interfaces, and I/O interfaces. The processing circuitry comprises DSPs, CPUs, GPUs, FPGAs, ASICs, and/or the like. The memory circuitry includes RAM, flash memory, disk drives, and/or the like. The memory stores software like operating systems, virtual layers, and virtual network elements. The virtual layers comprise operating systems, hypervisors, virtual switches, virtual machines, and the like. The virtual network elements comprise MME **121**, SGW **122**, and the like. The processing circuitry executes the operating systems, virtual layers, and network elements to exchange the user data and network signaling with wireless access point **110**.

Wireless access point **110** wirelessly serves UEs **101-103** with a media-conferencing service. UEs **101-103** and LTE DU **111** wirelessly exchange media conference data and signaling over LTE links **131-133**. LTE DU **111** and LTE CU **113** exchange the conference data and signaling over LTE link **137**. LTE CU **113** and MME **121** exchange conference signaling over LTE link **140**. LTE CU **113** and SGW **122** exchange conference data over LTE link **141**. MME **121** and SGW **122** exchange conference signaling over LTE link **142**.

LTE CU **113** determines media-conferencing load like the amount of UEs, links, resource blocks, and the like that currently serve the media-conferencing service. Based on the media-conferencing load, LTE CU **113** determines allocations between LTE and 5GNR for the internet-access service. LTE CU **113** increases the 5GNR allocation and decreases the LTE allocation when the media-conferencing load increases. LTE CU **113** decreases the 5GNR allocation and increases the LTE allocation when the media-conferencing load decreases. The allocations comprise a 5GNR Uplink (UL) allocation, LTE UL allocation, 5GNR Downlink (DL) allocation, and LTE DL allocation. LTE CU **112** transfers LTE signaling to LTE DU **111** indicating the LTE UL/DL allocations. LTE DU **111** transfers LTE signaling to UEs **101-103** indicating the LTE UL/DL allocations. LTE CU **112** transfers 5GNR signaling to 5GNR CU **114** indicating the 5GNR UL/DL allocations. 5GNR CU **114** transfers 5GNR signaling to 5GNR DU **112** indicating the 5GNR UL/DL allocations. 5GNR DU **112** transfers 5GNR signaling to UEs **101-103** indicating the 5GNR UL/DL allocations.

Wireless access point **110** wirelessly serves UEs **101-103** with the internet-access service per the 5GNR/LTE UL/DL allocations. UEs **101-103** and LTE DU **111** wirelessly exchange internet-access data and signaling over LTE links **131-133** per the LTE UL/DL allocations. UEs **101-103** and 5GNR DU **112** wirelessly exchange internet-access data and signaling over 5GNR links **134-136** per the 5GNR UL/DL allocations. For example, the LTE UL allocation might be 30% and the 5GNR UL allocation might be 70%, so 30% of the UL internet data traverses LTE links **131-133** and 70% of the UL internet data traverses 5GNR links **134-136**. LTE

DU **111** and LTE CU **113** exchange LTE internet-access data and signaling over LTE link **137**. 5GNR DU **112** and 5GNR CU **114** exchange 5GNR internet-access data and signaling over 5GNR link **138**.

LTE CU **113** and 5GNR CU **114** exchange internet-access data and signaling over X2 link **139** per the 5GNR UL/DL allocations. For example, the LTE DL allocation might be 20% and the 5GNR DL allocation might be 80%, so 20% of the DL internet data traverses LTE link **137** and 80% of the DL internet data traverses X2 link **139**. LTE CU **113** and MME **121** exchange internet-access signaling over LTE link **140**. LTE CU **113** and SGW **122** exchange internet-access data over LTE link **141**. MME **121** and SGW **122** exchange internet-access signaling over LTE link **142**. In some examples, 5GNR CU **114** and SGW **122** exchange internet-access data over 5GNR link **143**.

Advantageously, 5GNR/LTE access point **110** transfers the internet-access data over parallel 5GNR/LTE links **131-136** and **137-138** to efficiently and effectively support the media-conferencing service.

FIG. 2 illustrates the operation of wireless access point **110** to wirelessly serve UEs **101-103** with the media-conferencing service and the internet-access service. UEs **101-103** and LTE DU **111** wirelessly exchange conference data and signaling over LTE links **131-133** (**201**). LTE DU **111** and LTE CU **113** exchange the conference data and signaling over LTE link **137**. LTE CU **113** and MME **121** exchange conference signaling over LTE link **140**. LTE CU **113** and SGW **122** exchange conference data over LTE link **141**. MME **121** and SGW **122** exchange conference signaling over LTE link **142**.

LTE CU **113** determines media-conferencing load like the amount of UEs, links, resource blocks, and the like that serve media-conferencing (**202**). Based on the media-conferencing load, LTE CU **113** determines allocations between LTE and 5GNR for the internet access service (**203**). For example, LTE CU **113** may enter a data structure with the media-conference load value to yield the LTE and 5GNR UL and DL allocations. LTE CU **113** increases the 5GNR allocation and decreases the LTE allocation when the media-conferencing load increases. LTE CU **113** decreases the 5GNR allocation and increases the LTE allocation when the media-conferencing load decreases. The allocations comprise: a 5GNR UL allocation, LTE UL allocation, 5GNR DL allocation, and LTE DL allocation.

LTE CU **112** transfers LTE signaling to LTE DU **111** indicating the LTE UL/DL allocations (**204**). LTE DU **111** transfers LTE signaling to UEs **101-103** indicating the LTE UL/DL allocations. LTE CU **112** transfers 5GNR signaling to 5GNR CU **114** indicating the 5GNR UL/DL allocations. 5GNR CU **114** transfers 5GNR signaling to 5GNR DU **112** indicating the 5GNR UL/DL allocations. 5GNR DU **111** transfers 5GNR signaling to UEs **101-103** indicating the 5GNR UL/DL allocations.

UEs **101-103** and LTE DU **111** wirelessly exchange internet-access data and signaling over LTE links **131-133** per the LTE UL/DL allocations (**205**). UEs **101-103** and 5GNR DU **112** wirelessly exchange internet-access data and signaling over 5GNR links **134-136** per the 5GNR UL/DL allocations. LTE DU **111** and LTE CU **113** exchange LTE internet-access data and signaling over LTE link **137**. 5GNR DU **112** and 5GNR CU **114** exchange 5GNR internet-access data and signaling over 5GNR link **138**. LTE CU **113** and 5GNR CU **114** exchange internet-access data and signaling over X2 link **139** per the 5GNR UL/DL allocations. LTE CU **113** and MME **121** exchange internet-access signaling over LTE link **140**. LTE CU **113** and SGW **122** exchange internet-

access data over LTE link **141**. MME **121** and SGW **122** exchange internet-access signaling over LTE link **142**. The operation repeats (**201**).

FIG. 3 illustrates the operation of wireless access point **110** to wirelessly serve UE **101** and UE **104** with the media-conferencing service and the internet-access service. UE **101** and LTE DU **111** wirelessly exchange media data for the media-conferencing service. UE **104** and LTE DU **111** wirelessly exchange media data the media-conferencing service. LTE DU **111** and LTE CU **113** exchange the media data. LTE CU **113** and network core **120** exchange the media data.

LTE CU **113** determines the media-conferencing load like a number of media-conferencing UEs. Based on the media-conferencing load, LTE CU **113** determines allocations between LTE and 5G NR for the internet-access service for UEs **101** and **104**. LTE CU **112** transfers the LTE UL/DL allocations to LTE DU **111**. LTE DU **111** transfers the LTE UL/DL allocations to UEs **101** and **104**. LTE CU **112** transfers the 5G NR UL/DL allocations to 5G NR CU **114**. 5G NR CU **114** transfers the 5G NR UL/DL allocations to 5G NR DU **112**. 5G NR DU **112** transfers the 5G NR UL/DL allocations to UEs **101** and **104**.

UE **101** and LTE DU **111** wirelessly exchange internet data per the LTE UL/DL allocations. LTE DU **111** and LTE CU **113** exchange internet data. LTE CU **113** and core **120** exchange internet data. UE **101** and 5G NR DU **112** wirelessly exchange internet data per the 5G NR UL/DL allocations. 5G NR DU **112** and 5G NR CU **114** exchange internet data. 5G NR CU **114** and LTE CU **113** exchange internet data per the 5G NR UL/DL allocations. In some examples, 5G NR CU **114** also exchanges internet data with core **120** per the 5G NR UL/DL allocations.

UE **104** and LTE DU **111** wirelessly exchange internet data per the LTE UL/DL allocations. LTE DU **111** and LTE CU **113** exchange internet data. LTE CU **113** and core **120** exchange internet data. UE **104** and 5G NR DU **112** wirelessly exchange internet data per the 5G NR UL/DL allocations. 5G NR DU **112** and 5G NR CU **114** exchange internet data. 5G NR CU **114** and LTE CU **113** exchange internet data per the 5G NR UL/DL allocations. In some examples, 5G NR CU **114** also exchanges internet data with core **120** per the 5G NR UL/DL allocations.

FIG. 4 illustrates 5G NR/LTE UE **401** that is wirelessly served with a media-conferencing service and an internet-access service from 5G NR/LTE access points. 5G NR/LTE UE **401** is an example of UEs **101-103**, although UEs **101-103** may differ. 5G NR/LTE UE **401** comprises bus circuitry (cktry) **411**, processing circuitry **412**, memory circuitry **413**, user interface circuitry **414**, LTE radio circuitry **415**, and 5G NR radio circuitry **416**. User interface circuitry **415** may comprise transceivers, machine controllers, graphic displays, sensors, cameras, and/or some other user components. Bus circuitry **411** couples processing circuitry **412**, memory circuitry **413**, user interface circuitry **414**, LTE radio circuitry **415**, and 5G NR radio circuitry **416**.

Memory circuitry **413** comprises volatile and non-volatile memories like RAM, flash, disc, tape, and the like. Memory circuitry **413** stores an operating system (OS), network applications, and user applications for media-conferencing (MEDIA) and internet-access (INTERNET). The network applications comprise LTE PHY, LTE MAC, LTE RLC, LTE PDCP, LTE RRC, 5G NR PHY, 5G NR MAC, 5G NR RLC, 5G NR PDCP, 5G NR RRC, and 5G NR SDAP. Processing circuitry **412** comprises CPUs, GPUs, ASICs, FPGAs, and/or some other computer hardware. Processing circuitry **412** executes the operating system and user applications to

generate user data and signaling. Processing circuitry **412** executes the operating system and the network applications to drive radio circuitry **415-416** to wirelessly exchange user data and network signaling with 5G NR/LTE access points. Radio circuitry **415-416** each comprise antennas (ANT), duplexers (DUPLEX), filters, amplifiers (AMPS), modulators (MOD), Analog/Digital interfaces (A/D), DSP, CPU, and memory (MEM). The antennas in radio circuitry **415-416** exchange wireless signals that transport user data and network signaling with 5G NR/LTE access points. In radio circuitry **415-416**, the DSPs and CPUs execute software to drive the exchange of user data and network signaling between the antennas and memory circuitry **413**.

RRC functions comprise authentication, security, handovers, status reporting, Quality-of-Service (QoS), system broadcasts, and network pages. SDAP functions comprise QoS marking and flow control. PDCP functions comprise security ciphering, header compression and decompression, sequence numbering and re-sequencing, de-duplication. RLC functions comprise Automatic Repeat Request (ARQ), sequence numbering and resequencing, segmentation and resegmentation. MAC functions comprise buffer status, power headroom, channel quality, Hybrid Automatic Repeat Request (HARQ), user identification, random access, user scheduling, and QoS. PHY functions comprise packet formation/deformation, windowing/de-windowing, guard-insertion/guard-deletion, parsing/de-parsing, control insertion/removal, interleaving/de-interleaving, Forward Error Correction (FEC) encoding/decoding, rate matching/de-matching, scrambling/descrambling, modulation mapping/de-mapping, channel estimation/equalization, Fast Fourier Transforms (FFTs)/Inverse FFTs (IFFTs), channel coding/decoding, layer mapping/de-mapping, precoding, Discrete Fourier Transforms (DFTs)/Inverse DFTs (IDFTs), and Resource Element (RE) mapping/de-mapping.

Through the operating system, the media-conferencing application and the internet-access application exchange user data and signaling with the LTE RRC. The LTE RRC maps between the user data/network signaling and Service Data Units (SDUs). The LTE RRC exchanges data SDUs with the 5G NR SDAP and the LTE PDCP per the 5G NR/LTE allocations. The LTE RRC exchanges signaling SDUs with the 5G NR RRC and the LTE PDCP. The 5G NR PDCP and the LTE PDCP map between the SDUs and Protocol Data Units (PDUs). The PDCPs exchange the PDUs with the 5G NR RLC and the LTE RLC. The RLCs map between the PDUs and MAC logical channels. The RLCs exchange user data and network signaling with the 5G NR MAC and the LTE MAC over the MAC logical channels. The MACs map between the MAC logical channels and MAC transport channels. The MACs exchange user data and network signaling with the PHY over the MAC transport channels. The 5G NR PHY and the LTE PHY map between the MAC transport channels and PHY transport channels. The PHYs exchange user data and network signaling with PHYs in 5G NR/LTE access points over the PHY transport channels.

The LTE PHY stores Uplink (UL) user data and network signaling in the memory in LTE radio circuitry **415**. The 5G NR PHY stores UL user data and network signaling in the memory in 5G NR radio circuitry **416**. In radio circuitry **415-416**, the DSPs transfer corresponding UL signals to the analog/digital interface. The analog/digital interface converts the digital UL signals into analog UL signals for the modulators. The modulators up-convert the UL signals to their carrier frequencies. The amplifiers boost the UL signals for the filters which attenuate unwanted out-of-band energy. The filters transfer the UL signals through the duplexers to

the antennas. The electrical UL signals drive the antennas to emit corresponding wireless UL signals that transport UL data and signaling to 5G NR/LTE access points.

In radio circuitry **415-416**, the antennas receive wireless Downlink (DL) signals that transport user data and network signaling from 5G NR/LTE access points. The antennas transfer corresponding electrical DL signals through the duplexers to the amplifiers. The amplifiers boost the received DL signals for filters which attenuate unwanted energy. In modulation, demodulators down-convert the DL signals from their carrier frequencies. The analog/digital interfaces convert the analog DL signals into digital DL signals for the DSPs and CPUs. The DSPs and CPUs recover DL data from the DL signals that includes the user data and network signaling. The DSPs and CPUs transfer the DL user data and network signaling to memory circuitry **413**. The network applications process the DL user data and network signaling and forward corresponding data and signaling to the media-conferencing application and the internet-access application through the operating system. The media-conferencing application and the internet-access application process the data and signaling to drive user interface circuitry **414** through the operating system.

FIG. 5 illustrates 5G NR/LTE access point **510** to wirelessly serve UEs with a media-conferencing service and an internet-access service. 5G NR access point **510** comprises an example of wireless access point **110**, although access point **110** may differ. 5G NR access point **510** comprises LTE DU **520**, LTE CU **540**, 5G NR DU **560**, and 5G NR CU **580**. LTE DU **520** comprises antennas **521**, duplexers **522**, filters **523-524**, Low Noise Amplifier (LNA) **525**, Power amplifier (PA) **526**, modulators **527**, de-modulators **528**, D/A interfaces **529**, DSP/CPU **530**, and memory **531**. LTE CU **540** comprises processing circuitry **541**, memory circuitry **542**, bus circuitry **543**, and transceiver circuitry **544**.

Memory **531** and memory circuitry **542** comprise volatile and non-volatile memories like RAM, flash, and the like. Processing circuitry **541** comprises CPUs, GPUs, ASICs, FPGAs, and/or some other computer circuitry. In this example, memory **531** stores an operating system and the network applications for LTE PHY, LTE MAC, and LTE RLC while memory circuitry **542** stores an operating system and the network applications for LTE PDCP and LTE RRC. Other LTE protocol split options could be used in other examples.

DSP/CPU **530** and processing circuitry **541** execute the operating systems and network applications to exchange user data and network signaling with UEs over links **532**. DSP/CPU **530** and processing circuitry **541** execute the operating systems and network applications to exchange user data and network signaling with one another over links **533**. Processing circuitry **541** executes its operating system and network applications to exchange user data and network signaling with 5G NR CU **580** over links **546**. Processing circuitry **541** executes its operating system and network applications to exchange user data and network signaling with network cores over links **545**.

5G NR DU **540** comprises antennas **561**, duplexers **562**, filters **563-564**, LNA **565**, PA **566**, modulators **567**, de-modulators **568**, D/A interfaces **569**, DSP/CPU **570**, and memory **571**. 5G NR CU **580** comprises processing circuitry **581**, memory circuitry **582**, bus circuitry **583**, and transceiver circuitry **584**. Memory **571** and memory circuitry **582** comprise volatile and non-volatile memories like RAM, flash, and the like. Processing circuitry **581** comprises CPUs, GPUs, ASICs, FPGAs, and/or some other computer circuitry. In this example, memory **581** stores an operating

system and the network applications for 5G NR PHY, 5G NR MAC, and 5G NR RLC while memory circuitry **582** stores an operating system and the network applications 5G NR PDCP, 5G NR RRC, and 5G NR SDAP. Other 5G NR protocol split options could be used in other examples.

DSP/CPU **570** and processing circuitry **581** execute the operating systems and network applications to exchange user data and network signaling with UEs over 5G NR links **572**. DSP/CPU **570** and processing circuitry **581** execute the operating systems and network applications to exchange user data and network signaling with one another over links **573**. Processing circuitry **581** executes its operating system and network applications to exchange user data and network signaling with LTE CU **540** over links **546**. In some examples, processing circuitry **581** executes its operating system and network applications to exchange user data and network signaling with network cores over links **585**.

In LTE CU **540** and 5G NR CU **580**, the RRC functions comprise authentication, security, handovers, status reporting, QoS, system broadcasts, and network pages. SDAP functions comprise QoS marking and flow control. PDCP functions comprise security ciphering, header compression and decompression, sequence numbering and re-sequencing, de-duplication. RLC functions comprise ARQ, sequence numbering and resequencing, segmentation and resegmentation. MAC functions comprise buffer status, power headroom, channel quality, HARQ, user identification, random access, user scheduling, and QoS. PHY functions comprise packet formation/deformation, windowing/de-windowing, guard-insertion/guard-deletion, parsing/de-parsing, control insertion/removal, interleaving/de-interleaving, FEC encoding/decoding, rate matching/de-matching, scrambling/de-scrambling, modulation mapping/de-mapping, channel estimation/equalization, FFTs/IFFTs, channel coding/decoding, layer mapping/de-mapping, precoding, DFTs/IDFTs, and RE mapping/de-mapping.

In LTE CU **540**, the LTE RRC maps between user data/network signaling and SDUs. The LTE RRC exchanges data SDUs with the 5G NR SDAP over links **546** and with the LTE PDCP per the 5G NR/LTE allocations. The LTE RRC exchanges signaling SDUs with the 5G NR RRC over links **546** and the LTE PDCP. The 5G NR PDCP and the LTE PDCP map between the SDUs and Protocol Data Units (PDUs). The LTE PDCP exchanges the PDUs with the LTE RLC over links **533**. The 5G NR PDCP exchanges the PDUs with the 5G NR RLC over links **573**. The RLCs map between the PDUs and MAC logical channels. The RLCs exchange user data and network signaling with the 5G NR MAC and the LTE MAC over the MAC logical channels. The MACs map between the MAC logical channels and MAC transport channels. The MACs exchange user data and network signaling with the PHY over the MAC transport channels. The 5G NR PHY and the LTE PHY map between the MAC transport channels and PHY transport channels. The PHYs exchange user data and network signaling with PHYs in 5G NR/LTE access points over the PHY transport channels.

In LTE DU **520** and 5G NR DU **560**, antennas **521** and **561** receive wireless UL signals that transport user data and network signaling from UEs. Antennas **521** and **561** transfer corresponding electrical UL signals through the duplexers **522** and **562** to LNAs **525** and **565**. LNAs **525** and **565** boost the received UL signals for filters **524** and **564** which attenuate unwanted energy. Demodulators **528** and **568** down-convert the UL signals from their carrier frequencies. D/As **529** and **569** convert the analog UL signals into digital UL signals for DSP/CPU **530** and DSP/CPU **570**. DSP/CPU **530/570** execute the network applications to transfer

the DL user data and network signaling to memory circuitry **542** over links **533**. In LTE CU **540** and 5GNR CU **580**, the network applications process the UL user data and network signaling and transfer UL user data and network signaling to network cores over links **546**, links **545**, and possibly links **585**.

In LTE CU **540** and 5GNR CU **580**, the network applications receive DL user data and network signaling over links **546**, links **545**, and possibly links **585**. Circuitry **543-544** and **583-584** transfer the DL user data and network signaling to memory circuitry **582**. LTE CU **540** executes the operating system and user applications to transfer DL user data and network signaling per the 5GNR/LTE allocations from memory circuitry **542** to memory **531** over links **533** and from memory circuitry **542** to memory circuitry **582** over links **546**. In LTE DU **520** and 5GNR DU **560**, DSP/CPU **530** and DSP/CPU **570** execute the operating systems and network applications to transfer corresponding DL signals to the D/A **529** and D/A **569**. D/A **529** and D/A **569** convert the digital DL signals into analog DL signals for modulators **527** and **567**. Modulators **527** and **567** up-convert the DL signals to their carrier frequencies. PAs **526** and **566** boost the DL signals for filters **523** and **563** which attenuate unwanted out-of-band energy. Filters **523** and **563** transfer the DL signals through duplexers **522** and **562** to antennas **521** and **561**. The electrical UL signals drive antennas **521** and **561** to emit corresponding wireless DL signals that transport DL user data and network signaling to 5GNR/LTE UEs.

LTE DU **520** and UEs wirelessly exchange media conference data and signaling over links **532**. LTE DU **520** and LTE CU **540** exchange the conference data and signaling over link **533**. The LTE RRC in LTE CU **540** and an MME in a network core exchange conference signaling over link **545**. The LTE RRC in LTE CU **540** and an SGW in a network core exchange conference data over link **545**.

The LTE RRC in LTE CU **540** determines media-conferencing load like the average percent of available resource blocks that are used for the media-conferencing service. Based on the media-conferencing load, the LTE RRC in LTE CU **540** determines UL and DL allocations between LTE and 5GNR for the internet-access service. For example, the LTE RRC may enter a data structure with the number of voice-conference connections to yield the LTE UL allocation, LTE DL allocation, 5GNR UL allocation, and 5GNR DL allocation. The LTE RRC in LTE CU **540** transfers DL user data and signaling to the LTE PDCP per the LTE DL allocation and transfers DL user data and signaling to the 5GNR SDAP/RRC per the 5GNR DL allocation. For example, the LTE DL allocation might be 30% and the 5GNR DL allocation might be 70%. In access point **510**, the LTE RRC transfers 70% of the DL internet data over 5GNR links **546**, 5GNR CU **580**, 5GNR links **573**, 5GNR DU **560**, and 5GNR links **572**. The LTE RRC transfers 30% of the DL internet data over LTE CU **560**, LTE links **533**, LTE DU **520**, and LTE links **532**.

For the UL, the LTE RRC in LTE CU **540**, transfers RRC signaling to the LTE RRCs in the UEs indicating the LTE UL allocation and the 5GNR UL allocation. In the UEs, the LTE RRCs transfer UL user data and network signaling to the LTE PDCP per the LTE UL allocation and transfer UL user data and network signaling to the 5GNR RRC/SDAP per the 5GNR UL allocation. For example, the LTE UL allocation might be 20% and the 5GNR UL allocation might be 80%. In the UEs, the LTE RRCs transfer 20% of the UL internet data over LTE links **532** and transfer 80% of the UL internet data over 5GNR links **572**.

FIG. **6** illustrates the operation of 5GNR/LTE UE **401**, 5GNR/LTE access point **510**, and LTE network core **620** to serve 5GNR/LTE UE **401** with the media-conferencing and internet-access. For clarity, some circuitry and software from FIGS. **4-5** is omitted from FIG. **6**. At power-up, the LTE RRC in 5GNR/LTE UE **401** attaches to the LTE RRC in 5GNR/LTE access point **510** and then to the LTE MME in LTE core **620**. The LTE MME authorizes UE **401** for the media-conferencing and internet-access services. The LTE MME directs the LTE RRC in 5GNR/LTE access point **510** and an LTE Gateway (GW) to establish an internet-access bearer and an Internet-Protocol Multimedia Subsystem (IMS) bearer for UE **401**.

The LTE RRC in 5GNR/LTE access point **510** signals the LTE RRC in 5GNR/LTE UE **401** to establish an LTE internet-access bearer and an LTE IMS bearer. The LTE RRC in 5GNR/LTE access point **510** directs the 5GNR RRC in access point **510** to establish a 5GNR internet-access bearer. The LTE RRC in 5GNR/LTE UE **401** directs the 5GNR RRC in UE **401** to establish the 5GNR internet-access bearer. The 5GNR RRC in access point **510** signals the 5GNR RRC in UE **401** to establish the 5GNR internet-access bearer over the 5GNR SDAPs. The internet-access application in UE **401** may exchange internet data over the LTE internet-access bearer through the LTE RRCs and LTE GW and over the 5GNR internet-access bearer through the 5GNR SDAPs and LTE GW. In this example, the 5GNR internet-access bearer between the 5GNR SDAP in access point **510** and the LTE GW traverses the LTE RRC in access point **510**.

The IMS application in UE **401** may exchange conference signaling like Session Initiation Protocol (SIP) with the IMS in network core **620** over the LTE IMS bearer through the LTE RRCs and LTE GW. In response to the signaling, the IMS directs the LTE MME to establish another media-conferencing bearer for UE **401**. For example, UE may transfer a SIP INVITE to the IMS, and after IMS processing and SIP exchanges, the IMS directs the LTE MME to establish a Quality-of-Service (QoS) Class Indicator (QCI) 1 bearer for UE **401**. The LTE MME directs the LTE GW and the LTE RRC in 5GNR/LTE access point **510** to establish the media-conferencing bearer for UE **401** like the QCI 1 bearer. The LTE RRC in 5GNR/LTE access point **510** signals the LTE RRC in 5GNR/LTE UE **401** to establish the media-conferencing bearer. The IMS application in UE **401** may exchange media-conference data like voice and/or video over the media-conferencing bearer through the LTE RRCs and LTE GW.

The LTE RRC in 5GNR/LTE access point **510** determines a media-conference load for the UEs it serves—like the average number of QCI 1 bearers. The LTE RRC translates the media-conference load into UL/DL allocations for LTE and 5GNR internet-access. For example, the LTE RRC may translate the average number of QCI 1 bearers into the following allocations for internet access: 10% LTE UL, 90% 5GNR UL, 30% LTE DL, and 70% 5GNR DL.

For the internet-access service, the LTE RRC in 5GNR/LTE access point **510** implements the allocations for the UEs that it serves. On the DL, the LTE RRC in access point **510** receives internet data. The LTE RRC in access point **510** routes the 5GNR DL data allocation to the 5GNR SDAP and correspondingly signals the 5GNR RRC to direct the transfer. The 5GNR SDAPs and RRCs in access point **510** and UE **401** signal and transfer the 5GNR DL data allocation from access point **510** to UE **401**. The LTE RRC in access point **510** signals the LTE RRC in UE **401** of the LTE DL

allocation. The LTE RRC in access point **510** then transfers the LTE DL data allocation to the LTE RRC in UE **401**.

For the UL, the LTE RRC in access point **510** signals the LTE/5G NR UL allocations to the LTE RRC in 5G NR/LTE UE **401**. The LTE RRC in UE **401** routes the 5G NR UL data allocation to the 5G NR SDAP and correspondingly signals the 5G NR RRC to direct the transfer. The 5G NR SDAPs and RRCs in UE **401** and access point **510** signal and transfer the 5G NR UL data allocation from UE **401** to access point **510**. The 5G NR SDAP in access point **510** transfers the 5G NR UL data allocation to the LTE RRC in access point **510**. The LTE RRC in access point **510** transfers the 5G NR UL data allocation to the LTE GW for internet-access.

FIG. 7 illustrates the operation of 5G NR/LTE UE **401**, 5G NR/LTE access point **510**, and LTE network core **620** to serve 5G NR/LTE UE **401** with the media-conferencing and internet-access. For clarity, some circuitry and software from FIGS. 4-5 is omitted from FIG. 7. At power-up, the LTE RRC in 5G NR/LTE UE **401** attaches to the LTE RRC in 5G NR/LTE access point **510** and then to the LTE MME in LTE core **620**. The LTE MME authorizes UE **401** for the media-conferencing and internet-access services. The LTE MME directs the LTE GW and the LTE RRC in 5G NR/LTE access point **510** to establish an internet-access bearer and an IMS bearer for UE **401**.

The LTE RRC in 5G NR/LTE access point **510** signals the LTE RRC in 5G NR/LTE UE **401** to establish an LTE internet-access bearer and an LTE IMS bearer. The LTE RRC in 5G NR/LTE access point **510** directs the 5G NR RRC in access point **510** to establish a 5G NR internet-access bearer. The LTE RRC in 5G NR/LTE UE **401** directs the 5G NR RRC in UE **401** to establish the 5G NR internet-access bearer. The 5G NR RRC in access point **510** signals the 5G NR RRC in UE **401** to establish the 5G NR internet-access bearer over the 5G NR SDAPs. The internet-access application in UE **401** may exchange internet data over the LTE internet-access bearer through the LTE RRCs and LTE GW and over the 5G NR internet-access bearer through the 5G NR SDAPs and LTE GW. In this example, the 5G NR internet-access bearer between the 5G NR SDAP in access point **510** and the LTE GW is direct and does not traverse the LTE RRC in access point **510**.

The IMS application in UE **401** may exchange conference signaling like SIP with the IMS in network core **620** over the LTE IMS bearer through the LTE RRCs and LTE GW. In response to the signaling, the IMS directs the LTE MME to establish another media-conferencing bearer for UE **401**. For example, UE may transfer a SIP INVITE to the IMS, and after IMS processing and SIP exchanges, the IMS directs the LTE MME to establish a QCI 3 bearer for UE **401**. The LTE MME directs the LTE GW and the LTE RRC in 5G NR/LTE access point **510** to establish the media-conferencing bearer for UE **401** like the QCI 3 bearer. The LTE RRC in 5G NR/LTE access point **510** signals the LTE RRC in 5G NR/LTE UE **401** to establish the media-conferencing bearer. The IMS application in UE **401** may exchange media-conference data like voice and/or video over the LTE media-conferencing bearer through the LTE RRCs and LTE GW.

The LTE RRC in 5G NR/LTE access point **510** determines a media-conference load for the UEs it serves—like the average number of QCI 3 bearers. The LTE RRC translates the media-conference load into UL/DL allocations for LTE and 5G NR internet-access. For example, the LTE RRC may translate the average number of QCI 3 bearers into the

following allocations for internet access: 10% LTE UL, 90% 5G NR UL, 20% LTE DL, and 80% 5G NR DL.

For the internet-access service, the LTE RRC in 5G NR/LTE access point **510** implements the allocations for the UEs that it serves. On the DL, the LTE RRC in access point **510** signals the 5G NR/LTE DL allocations to the LTE MME. The LTE MME signals the 5G NR/LTE DL allocations for UE **401** to the LTE GW. The LTE RRC in access point **510** signals the LTE DL allocation to the LTE RRC in UE **401**. The LTE RRC in access point **510** signals the 5G NR DL allocation to the 5G NR RRC in access point **510**. The 5G NR RRC in access point **510** signals the 5G NR DL allocation to the 5G NR RRC in UE **401**. The LTE GW receives DL internet data for UE **401** and routes the 5G NR DL allocation to the 5G NR SDAP in access point **510**. The LTE GW routes the LTE DL allocation to the LTE RRC in access point **510**. In access point **510**, the 5G NR SDAP transfers the 5G NR DL allocation to the 5G NR SDAP in UE **401**, and the LTE RRC transfers the LTE DL allocation to the LTE RRC in UE **401**.

The LTE RRC in access point **510** signals the LTE/5G NR UL allocations to the LTE RRC in 5G NR/LTE UE **401**. On the UL, the LTE RRC in UE **401** routes the 5G NR UL data allocation to the 5G NR SDAP and correspondingly signals the 5G NR RRC to direct the transfer. The 5G NR SDAPs and RRCs in UE **401** and access point **510** signal and transfer the 5G NR UL data allocation from UE **401** to access point **510**. The 5G NR SDAP in access point **510** transfers the 5G NR UL data allocation to the LTE GW in LTE core **620**. The LTE RRCs in UE **401** and access point **510** signal and transfer the LTE UL data allocation from UE **401** to access point **510**. The LTE RRC in access point **510** transfers the LTE UL data allocation to the LTE GW in LTE core **620**.

The wireless data network circuitry described above comprises computer hardware and software that form special-purpose wireless network circuitry to load balance internet-access data between 5G NR and LTE based on media-conferencing load. The computer hardware comprises processing circuitry like CPUs, DSPs, GPUs, transceivers, bus circuitry, and memory. To form these computer hardware structures, semiconductors like silicon or germanium are positively and negatively doped to form transistors. The doping comprises ions like boron or phosphorus that are embedded within the semiconductor material. The transistors and other electronic structures like capacitors and resistors are arranged and metallurgically connected within the semiconductor to form devices like logic circuitry and storage registers. The logic circuitry and storage registers are arranged to form larger structures like control units, logic units, and Random-Access Memory (RAM). In turn, the control units, logic units, and RAM are metallurgically connected to form CPUs, DSPs, GPUs, transceivers, bus circuitry, and memory.

In the computer hardware, the control units drive data between the RAM and the logic units, and the logic units operate on the data. The control units also drive interactions with external memory like flash drives, disk drives, and the like. The computer hardware executes machine-level software to control and move data by driving machine-level inputs like voltages and currents to the control units, logic units, and RAM. The machine-level software is typically compiled from higher-level software programs. The higher-level software programs comprise operating systems, utilities, user applications, and the like. Both the higher-level software programs and their compiled machine-level software are stored in memory and retrieved for compilation and execution. On power-up, the computer hardware automati-

cally executes physically-embedded machine-level software that drives the compilation and execution of the other computer software components which then assert control. Due to this automated execution, the presence of the higher-level software in memory physically changes the structure of the computer hardware machines into special-purpose wireless network circuitry wireless network circuitry to load balance internet-access data between 5G NR and LTE based on media-conferencing load.

The above description and associated figures teach the best mode of the invention. The following claims specify the scope of the invention. Note that some aspects of the best mode may not fall within the scope of the invention as specified by the claims. Those skilled in the art will appreciate that the features described above can be combined in various ways to form multiple variations of the invention. Thus, the invention is not limited to the specific embodiments described above, but only by the following claims and their equivalents.

What is claimed is:

1. A method of operating a wireless access point to wirelessly serve User Equipment (UEs) with a media-conferencing service and an internet-access service, the method comprising:

a Long Term Evolution (LTE) Common Unit (CU) exchanging media-conferencing data for the media-conferencing service with an LTE Distributed Unit (DU);

the LTE DU exchanging the media-conferencing data with the LTE CU and exchanging the media-conferencing data with the UEs;

the LTE CU determining a media-conferencing load, and based on the media-conferencing load, determining a Fifth Generation New Radio (5G NR) Uplink (UL) allocation and an LTE UL allocation for the internet-access service, transferring LTE signaling to the LTE DU indicating the LTE UL allocation, and transferring 5G NR signaling to a 5G NR CU indicating the 5G NR UL allocation;

the 5G NR CU receiving the 5G NR signaling and transferring the 5G NR signaling to a 5G NR DU;

the LTE DU receiving the LTE signaling and transferring the LTE signaling to the UEs;

the 5G NR DU receiving the 5G NR signaling and transferring the 5G NR signaling to the UEs;

the LTE DU receiving LTE UL internet data from the UEs per the LTE UL allocation and transferring the LTE UL internet data to the LTE CU; and

the 5G NR DU receiving 5G NR UL internet data from the UEs per the 5G NR UL allocation and transferring the 5G NR UL internet data to the 5G NR CU.

2. The method of claim 1 further comprising:

the LTE CU determining a 5G NR Downlink (DL) allocation and an LTE DL allocation for the internet-access service based on the media-conferencing load wherein the 5G NR signaling indicates the 5G NR DL allocation and the LTE signaling indicates the LTE DL allocation; the LTE CU transferring LTE DL internet data to the LTE DU per the LTE DL allocation and transferring 5G NR DL internet data to the 5G NR CU per the 5G NR DL allocation; and

the 5G NR CU transferring 5G NR DL internet data to the 5G NR DU; and

the 5G NR DU receiving the 5G NR DL internet data from 5G NR CU and transferring the 5G NR DL internet data to the UEs.

3. The method of claim 1 further comprising the LTE CU transferring the LTE UL internet data for delivery to a network gateway.

4. The method of claim 1 further comprising the 5G NR CU transferring the 5G NR UL internet data for delivery to a network gateway.

5. The method of claim 1 further comprising:
the 5G NR CU transferring the 5G NR UL internet data to the LTE CU; and

the LTE CU transferring the 5G NR UL internet data for delivery to a network gateway.

6. The method of claim 1 further comprising the LTE CU exchanging the media-conferencing data with a network gateway.

7. The method of claim 1 wherein the media-conferencing service comprises a voice-calling service.

8. The method of claim 1 wherein the media-conferencing service comprises a video-conferencing service.

9. The method of claim 1 wherein the LTE CU determining the 5G NR UL allocation comprises increasing the 5G NR UL allocation when the media-conferencing load increases.

10. The method of claim 1 wherein the LTE CU determining the LTE UL allocation comprises decreasing the LTE UL allocation when the media-conferencing load increases.

11. A wireless access point to wirelessly serve User Equipment (UEs) with a media-conferencing service and an internet-access service, the wireless access point comprising:

a Long Term Evolution (LTE) Common Unit (CU) configured to exchange media-conferencing data for the media-conferencing service with an LTE Distributed Unit (DU);

the LTE DU configured to exchange the media-conferencing data with the LTE CU and exchange the media-conferencing data with the UEs;

the LTE CU configured to determine a media-conferencing load, and based on the media-conferencing load, determine a Fifth Generation New Radio (5G NR) Uplink (UL) allocation and an LTE UL allocation for the internet-access service, transfer LTE signaling to the LTE DU indicating the LTE UL allocation, and transfer 5G NR signaling to a 5G NR CU indicating the 5G NR UL allocation;

the 5G NR CU configured to receive the 5G NR signaling and transfer the 5G NR signaling to a 5G NR DU;

the LTE DU configured to receive the LTE signaling and transfer the LTE signaling to the UEs;

the 5G NR DU configured to receive the 5G NR signaling and transfer the 5G NR signaling to the UEs;

the LTE DU configured to receive LTE UL internet data from the UEs per the LTE UL allocation and transfer the LTE UL internet data to the LTE CU; and

the 5G NR DU configured to receive 5G NR UL internet data from the UEs per the 5G NR UL allocation and transfer the 5G NR UL internet data to the 5G NR CU.

12. The wireless access point of claim 11 further comprising:

the LTE CU configured to determine a 5G NR Downlink (DL) allocation and an LTE DL allocation for the internet-access service based on the media-conferencing load wherein the 5G NR signaling indicates the 5G NR DL allocation and the LTE signaling indicates the LTE DL allocation;

the LTE CU configured to transfer LTE DL internet data to the LTE DU per the LTE DL allocation and transfer 5G NR DL internet data to the 5G NR CU per the 5G NR DL allocation; and

the 5G NR CU configured to transfer 5G NR DL internet data to the 5G NR DU; and
 the 5G NR DU configured to receive the 5G NR DL internet data from 5G NR CU and transfer the 5G NR DL internet data to the UEs.

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13. The wireless access point of claim **11** further comprising the LTE CU configured to transfer the LTE UL internet data for delivery to a network gateway.

14. The wireless access point of claim **11** further comprising the 5G NR CU configured to transfer the 5G NR UL internet data for delivery to a network gateway.

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15. The wireless access point of claim **11** further comprising:

the 5G NR CU configured to transfer the 5G NR UL internet data to the LTE CU; and

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the LTE CU configured to transfer the 5G NR UL internet data for delivery to a network gateway.

16. The wireless access point of claim **11** further comprising the LTE CU configured to exchange the media-conferencing data with a network gateway.

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17. The wireless access point of claim **11** wherein the media-conferencing service comprises a voice-calling service.

18. The wireless access point of claim **11** wherein the media-conferencing service comprises a video-conferencing service.

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19. The wireless access point of claim **11** wherein the LTE CU is configured to increase the 5G NR UL allocation when the media-conferencing load increases.

20. The wireless access point of claim **11** wherein the LTE CU is configured to decrease the LTE UL allocation when the media-conferencing load increases.

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